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Managing whiteflies in high tunnels and greenhouses

Whiteflies are small sap-sucking hemipterans that belong to the subfamily Aleyrodoidea. They are not true flies. They are year-round pests in greenhouses. In high tunnels, whiteflies can be active until early winter.

Life cycle

The life stages of whiteflies overlap, so throughout the year, growers may simultaneously see eggs, nymphs, pupae and adults. Females lay eggs on the underside of leaves. Hatching occurs within 10 days. Upon hatching, the nymph crawls until it finds a suitable place to feed. Then, a whitefly inserts its stylet (mouth part) into plant tissues and remains there feeding for about a month, while passing through four stages of development (Figure 1). Unlike most sucking insects, whiteflies have a resting stage (pupa) before becoming adults. Whiteflies complete their life cycle in 21 to 36 days.

Figure 1. Whiteflies feed on the plant phloem. (Photo credit: C. Quesada)

Plant damage and scouting

Whiteflies feed on the plant phloem, they excrete honeydew in which sooty mold can grow and they reduce photosynthesis. Also, high infestations of whiteflies can cause plant distortion, chlorotic spots, leaf yellowing, shedding and serious losses in some vegetable crops. While feeding, whiteflies inject salivary fluids, which can result in plant disorders and transmission of plant viruses. When viral pathogens are present, their transmission creates the greatest threat to the economical production of many crops. Yellow sticky cards are commonly used to monitor whiteflies, but they are not effective as a control method.

Biological control

Natural enemies are known to work well in controlling whiteflies. Lacewings, minute pirate bugs, Asian multicolored lady beetles and *Delphastus Catalinae* beetles are all common predators of whiteflies. Parasitoids, such as *Encarsia Formosa* and *Eretmocerus Eremicus*, also can be effective. These predators and parasitoids can be naturally present in West Virginia, but they also are commercially available. However, augmentative biocontrol (release of natural enemies) is more effective for greenhouses.

Cultural control

One of the most recommended cultural actions is to regularly monitor plants. Other recommendations consist of removing common host plant species, isolating new shipments for a period of time, keeping nearby plant residue buildup to a minimum and crop rotation.

Chemical control

Chemical control, the use of insecticides, is the primary method used to control whiteflies. The most effective active ingredients against whiteflies are imidacloprid and dinotefuran. To avoid insecticide resistance, imidacloprid and dinotefuran should be rotated with other less effective products. Those products can be afidopyropen, chloratraniliprole, cyclaniliprole, flonicamid, flupyradifurone, pyrifluquinazon, spirotetramat and sulfoxaflor + spinetoram. Ornamental oils and insecticidal soaps are not effective against whiteflies.

Identification and management of boxwood blight

Boxwoods (Buxus spp.) are one of the most popular shrubs used in West Virginia landscapes. It is not unlikely to find diverse cultivars of boxwoods in landscapes across the state. With the increased population and high-density landscape settings, certain diseases like boxwood blight have become very destructive.

Boxwood blights are a fungal disease that can be fatal if no measures are taken to manage the disease at the early stage of infection and symptom appearance. There are two different fungal pathogens involved with blights – *Volutella buxi* and *Calonectria pseudonaviculata*.

A Volutella buxi infection turns leaves light green-yellow, which transition to bronze and finally become yellow-tan in color (Table 1-A). This is known as Volutella blight. This fungal pathogen also can infect stems, resulting in loose or peeling, yellowish bark.

Another fungal pathogen known as Calonectria pseudonaviculata (previously called *Cylindrocladium pseudonaviculatum* or *Cylindrocladium buxicola*) can cause boxwood blight that may be termed as Calonectria blight. Unlike Volutella blight, infection from Calonectria manifests as dark leaf spots that coalesce to form brown blotches. While Volutella-affected leaves can be attached to the stem for a longer time, Calonectria-affected leaves drop off very quickly, known as defoliation, giving the plant a barren appearance (Table 1-B)

A key symptom that differentiates Calonectria blight from Volutella blight of boxwood is that narrow vertical black streaks (cankers) develop on green stems due to Calonectria infection, while Volutella-infected stems show brown to black girdling streaks, followed by loosening or peeling of the bark (Table 1-C).

Diagnosis of the disease

In moist conditions, orange or salmon colored fungal fruiting structures (sporodochia) are noticeable on stems or the underside of leaves in case of Volutella blight. One can take a few suspected leaves and put them inside a zip-close plastic bag with a moist paper towel for three to four days to observe such growth. The undersides of infected leaves in case of Calonectria blight will mostly show white sporulation (Table 1-D). The shape and size of spore (conidia) are also different for Volutella and Calonectria. However, this difference can only be observed under a microscope with high (400X) magnification capacity (Table 1-E).

Survival and spread of the pathogen

Both fungal pathogens can survive on infected plants or fallen leaves on the ground from one year to another, known as overwintering. The spores produced on infected leaves and stems during the growing season can be splash-dispersed through irrigation, rainfall, wind or pruning tools. This can spread the disease within a plant or to nearby boxwood shrubs. Environmental stress, such as drought, excessive water or winter injury, can make boxwood plants vulnerable to infections.

Recent outbreaks of Volutella blight in West Virginia and neighboring states may have a connection with the cold stress from the arctic blast that occurred in December 2022. While Volutella blight was present in the state of West Virginia and is considered an opportunistic pathogen that infects only stressed plants to make it endemic, Calonectria blight is more aggressive, but occurrences in the state remain very low. However, there is a potential for Calonectria-infected plants to arrive to the area on new plants through nursery trade. Homeowners and landscapers should make sure that infected plants are not purchased and planted.

Disease management

Prune out infected branches and destroy them by burning or hauling away in a trash bag. Pruning dense shrubs also can help in air movement, sunlight penetration and keeping canopy humidity low. Sanitize pruning tools by dipping in 10% bleach or 70% ethyl alcohol between each cut. Do not prune when foliage is wet. If possible, remove infected fallen leaves and litters.

Alleviate plant stress by providing irrigation and fertilization as needed. However, it is better to irrigate through drip irrigation and avoid overhead sprinkler to keep foliage dry. Do not use horticultural fabric as a mulch to suppress weed growth. It is better to use bark or compost mulch that may help retain moisture and promote root growth.

Alternative mosts and relative susceptibility

Pathogens from these genera can also affect Pachysandra and Sarcococca. American, English and Korean boxwoods are all susceptible to blight, although disease severity varies among cultivars. For example, boxwood cultivars Green Velvet, Green Mound, Green Mountain and Pincushion have some resistance against Volutella blight compared to highly susceptible cultivar Green Gem. Similarly, cultivars Golden Dream, Green Beauty and National are resistant, but Suffruiticosa, Arborescens and Justin Brouwers cultivars are highly susceptible to Calonectria blight. It is interesting to note that cultivar

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Identification and management of boxwood blight – *continued from page 2*

Green Gem is tolerant to Calonectria blight but the most susceptible to Volutella blight.

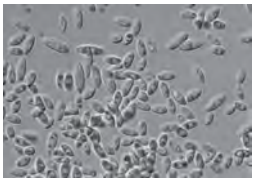
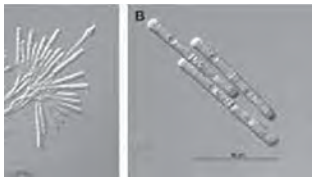
Chemical control of these two diseases is also a little different. That's why it is very critical to identify the disease accurately. If you suspect boxwood blight, send samples to the WVU Plant Diagnostic Clinic for diagnosis.

Fungicidal control

A combination of chlorothalonil (trade names include Bravo, Daconil or Fung-onil) and thiophanate methyl (Cleary 3336) can provide good control of Volutella blight if used preventatively or at the very early stage of symptom expression. Application of azoxystrobin (Heritage) in our trial also provided significant disease control. Removal of highly infected stems by pruning before fungicide application can improve the efficacy of the products. Other products that are registered for the control of Volutella blight include propiconazole, copper and mancozeb.

For preventing Calonectria blight, fungicides Heritage, Medallion, Mural can be used in alternation with Daconil.

Table 1. Differentiating boxwood blight caused by Volutella buxi (Volutella blight-VB) and Calonectria pseudonaviculata (Calonectria blight-CB).

Symptom Description	Volutella blight	Calonectria blight
A. Leaf symptom (VB: lesions are of irregular shape with undefined margins; CB: round with dark margin)		
B. Whole plant symptom (VB: tan-straw color leaves attached to the stem; CB: rapid defoliation)		
C. Stem symptom (VB: brown girdling streaks & loose bark; CB: black elongated vertical reaks)		
D. Fungal growth after incubation (VB: orange to salmon color; CB: whitish)		
E. Fungal spores (conidia; VB: small, elliptical; CB: large, cylindrical)		

(Photo credit: MM Rahman, WVU; ipm.missouri.edu/MEG/2019/5/volutella/; bygl.osu.edu/node/1359; www.bartlett.com/blog/how-to-prevent-boxwood-blight/; www.indystar.com/story/entertainment/2018/10/25/hoosier-gardener-deadly-boxwood-blight-found-indiana/1754110002/)

When to prune trees and shrubs

When to prune trees and shrubs is one question that puzzles many people. Even professionals often have different opinions about the best time to prune.

A good starting point would be to avoid times when there is an eminent threat of stress due to environmental conditions, such as high temperatures, drought or flooding. Through research and experience, recommendations also include avoiding periods when there is potential for certain disease infections and pest intrusion.

Pruning at planting time

Fall is a great time to make additions to your landscape. That also is the time when first and major mistakes are made about pruning by not pruning the newly added plants. It is important to start early and give your tree and/or shrub a good start by initiating a good structure for a good and healthy life.

Figure 2. Co-dominant leader and bark inclusion. (Photo credit: Mirjana Bulatovic-Danilovich)

It is always best to be proactive and prevent problems from developing than react to it. Such would be the case if planting a tree with codominant leaders that, in time, would have a very weak spot due to very sharp angle codominant leaders forming and bark inclusion, leading to a zone of decay that is weak and prone to breaking (Figure 2).

Timing for maintenance pruning

Another common question is when to conduct maintenance pruning on trees. One of the answers would be "whenever you have sharp pruners." That is not far from the truth.

In addition to avoiding the periods when the trees are under stress due to the environmental conditions, pruning at the beginning of the season during the flush growth should be avoided due to energy being directed to flowering and shoot elongation with little left for defense against ever-present pathogens and insects looking for the opportunity to invade the trees.

Figure 3. Apple tree before pruning and same tree after pruning. (Photo credit: Mirjana Bulatovic-Danilovich)

Some studies in Europe indicate that summer is an excellent time for pruning. Trees respond well to it by healing the cuts rapidly due to an air-drying effect.

Also, all protective tree systems are engaged and potential for infections is greatly diminished. Physiological response to summer pruning is much less vigorous than the response to the winter and very early spring pruning.

Late summer and early fall pruning also should be avoided since it might trigger late growth, delaying dormancy and making those shoots susceptible to early frost and winter injury.

Moderate and heavy pruning or structural pruning are best left for very late fall, winter and very early spring (Figure 3), in other words, during the

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When to prune trees and shrubs – *continued from page 4*

dormancy period. Popularity of this timing stems from the fact that pathogens are not active at that time.

Pruning flowering shrubs

The important consideration for flowering shrubs is when do they form the flowering buds: are they formed on new, or the current season's, shoots or do they form buds on the shoots from last year? If they are flowering on the current season's shoots, it does not matter when as long as you prune before the new shoots start elongating and growing.

If you prune when the new shoots are already formed, you may cut all the potential flowers for the season.

Plants that flower in spring, like azalea, rhododendron, forsythia, redbud and dogwood, are best pruned after they flower. If pruned in late fall and winter or early spring before bloom, most of the flower buds will be cut off, reducing the flowering potential.

The summer and late-summer flowering plants could be pruned in early spring just before the new season's growth flush. Suggestions for pruning commonly found trees and shrubs in our landscapes are presented in Tables 2 and 3.

Tables 2 and 3. Suggested timing for pruning common flowering trees and shrubs.

Prune after flowering	
Azalea	Pyracantha
Bigleaf hydrangea	Redbud
Dogwood	Magnolia (Saucer and Star)
Flowering almond	Spirea
Forsythia	Viburnum
Japanese pieris (Pieris japonica)	Weigelia
Honeysuckle	Winter Daphne
Lilac	Wisteria
Mockorange	Witch hazel
Oakleaf hydrangea	

Prune in very late fall, winter or early spring (during dormancy)	
Apple	Holly
Apricot	Hedges
Beautyberry	Japanese barberry
Bradford pear	Nandina
Camellia	Peach
Cranberry viburnum	Pear
Crape myrtle	Plum
Goldenrain tree	Roses
Grapes	Rose-of-Sharon

Using a handheld weed wiper to control mugwort in a landscape

Weeds in a landscape can be aesthetically unpleasant and can deter the growth of desirable plantings. Invasive weeds are most effectively controlled during early stages of establishment.

Once established, it can be difficult to control them, demanding much time and effort. Preventive measures, such as monitoring and maintaining the surrounding landscape, can be effective to keep them at bay.

Once they are detected in the landscape, the control method chosen may depend primarily on the life cycle of the weed and the level of infestation.

Physical methods, such as hand-weeding or use of simple tools, are effective for annual weeds or certain perennial weeds when they are present in small numbers.

Systemic herbicides can be effective to control perennial weeds by killing the underground organs, such as rhizomes or rootstocks, that are difficult to be removed mechanically.

While applying herbicides in a landscape or garden, it is critical to direct the herbicide towards target weeds to prevent injury of desirable plantings.

Directed sprays or spot treatment can be effective when there is adequate distance between the target weeds and desirable plants.

A handheld weed wiper can be used to control weeds when there is a risk of non-target injury to ornamental plantings from an herbicide. This involves saturating an absorbent material, such as brush or sponge, with a solution of a systemic non-selective herbicide, such as glyphosate, and wetting the weed shoots by wiping it on to them carefully.

Figure 4. Mugwort (Artemisia vulgaris) is a troublesome perennial broadleaf in the landscape and in gardens (inset shows upper and lower surfaces of a mugwort leaf for identification). (Photo credit: R.S. Chandran)

Figure 5. Extensive rhizomes of mugwort make it difficult to control. (Photo credit: R.S. Chandran)

Research was carried out at WVU to determine the optimal concentration glyphosate solution and surface area of weed foliage to obtain adequate control.

Mugwort (*Artemisia vulgaris*) is a perennial broadleaf weed with extensive rhizomes that can be difficult to control in the landscape and in gardens (Figures 4 and 5).

It is native to Eurasia but has been naturalized in North America since the early settlers. It is considered to be one of the worst weeds by the American nursery industry.

One of the most striking characteristics of mugwort is the silvery appearance of its lower leaf surface from tiny, densely-packed, wooly hairs.

Mugwort blooms from July to October with clusters of relatively inconspicuous flowers that are yellowish green in color, lacking petals. Mugwort seeds are not considered to be viable.

We used a handheld weed wiper (1-inch foam brush) to selectively control established mugwort in a landscape by applying the herbicide solution directly on to the weed.

Glyphosate (Roundup WeatherMax formulation) was wiped on mugwort plants during the early bloom stage (September 10, 2021) while they were 2 to 3 feet tall.

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Using a handheld weed wiper to control mugwort in a landscape – *continued from page 6*

We used a 4%, 25% or 50% solution (volume/volume) of the herbicide formulation wiped on approximately 10 fully expanded leaves, approximately 6 inches along the stem, bidirectionally on each emerged shoot (Figure 6).

All treatments resulted in excellent control (>95%) of mugwort based on visual injury ratings recorded for a period of six weeks after treatment.

Individual shoots of mugwort left unwiped in the immediate vicinity of wiped shoots continued to grow during the period under evaluation.

We concluded that selective in-season control of established mugwort shoots can be obtained by wiping a fully loaded (5.5 pounds per gallon) formulation glyphosate solution at a concentration of 4% volume/volume bidirectionally on to approximately 10 fully expanded mugwort leaves (six inches lengthwise along the stem) (Figures 7A and 7B).

While using a handheld weed wiper, use a pair of chemical-resistant gloves to minimize contact with the herbicide.

Additional precautions, such as wearing a long-sleeved shirt, long pants and closed toe shoes, should also be taken.

Figure 6. Using a handheld weed wiper such as a saturated foam brush to apply the herbicide solution on to weed shoots. (Photo credit: R.S. Chandran)

Depending on how established the mugwort plants are or how extensive the rhizomes are, sequential treatments may be needed during the following years.

The number of shoots in a mugwort colony that reemerge would be fewer and shorter and can eventually be eradicated from small areas following wiper applications once a year for a period of three to five years.

Figures 7A and 7B. Selective in-season control of mugwort (7A before treatment) following wiping a 4% (vol/vol) of glyphosate solution on to mugwort shoots (7B after treatment). (Photo credit: R.S. Chandran)

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